AGENDA

11:00 – 11:15	Introduction – Doug Sandberg
11:15 - 12:15	LBNL Case Studies – Bill Tschudi
12:15 – 1:15	Working Lunch – Bill Tschudi and Dave Coup
	Discuss Data Center Research Roadmap
1:15 – 2:00	Data Center Thermal Management – Roger Schmidt
2:00 – 2:15	Break
2:15 – 3:30	NYSERDA – Peter Douglas
	Programs to Support Energy Efficiency in Data Centers

Data Center Research

Sponsored by:

New York State

Energy Research Authority

and the

California Energy Commission

Bill Tschudi
Lawrence Berkeley National Laboratory

Acknowledgements

NYSERDA

California Energy Commission

Pacific Gas and Electric Company

7 x 24 Exchange

E Source

Syska & Hennessy

Rumsey Engineers

Uptime Institute

RMI

Industry Partners (Too many to name all)

We also operate data centers …

Why Look at Data Centers?

- Utilities were receiving requests for unrealistic power densities
- A lot of misinformation was circulating
- Large continually operating base loads
- Other High-Tech buildings energy efficiency opportunities were very large
- Technology improvements are transferable to other other building types

April 10, 2003 San Jose Mercury News

“A new power plant is up and running in San Jose's Alviso neighborhood, but the massive Internet server farm that it was supposed to fuel is nowhere in sight.

The Los Esteros Critical Energy Facility, a 180-megawatt plant built by Calpine in North San Jose, was designed to power an adjacent Internet server farm by U.S. Dataport. The server farm never broke ground -- and company officials didn't return calls Wednesday to say if or when it might -- but Calpine proceeded with the plant anyway, after securing a three-year deal with the state Department of Water Resources to buy power.

Company and state officials say the plant is still needed, even though the state's infamous energy crunch of 2000-01 is long over.”

180 MW: 900,000 sq.ft. x 200 W/sq.ft

New York Data Center Activities

- Case Study of an older facility used as a recovery center
- Case Study of a financial institution with increasing energy intensity
- Collaboration with California leverages data center research - such as development of an energy research roadmap

California Data Center Activities

- Case Studies and Energy Benchmarking
- Characterize CA Market
- Public Interest Energy Research Roadmap

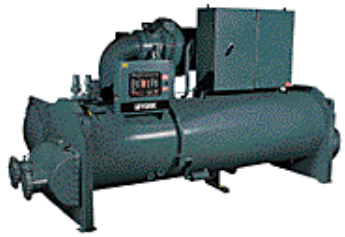
Case Studies/Benchmarks

- New York - NYSERDA
  - Recovery Center – Upstate New York
  - Financial Institution – New York, NY
- California - 6 Data Centers at 4 Sites
  - Storage Device Mfg. – 2 data centers, Sunnyvale CA
  - Bank – San Francisco, CA
  - Web hosting – 2 data centers - San Jose, CA
  - State facility – Sacramento, CA

Case Studies/Benchmarks

- Federal Energy Management Program
  - Federal facility – 2 data centers, Fresno, CA
  - LBNL operated data center – Oakland, CA
- Jennifer Mitchell-Jackson Case Study

Electricity Flows in Data Centers



HVAC system

local distribution lines

lights, office space, etc.

uninterruptible load

to the building, 480 V

UPS

PDU

computer racks

computer equipment

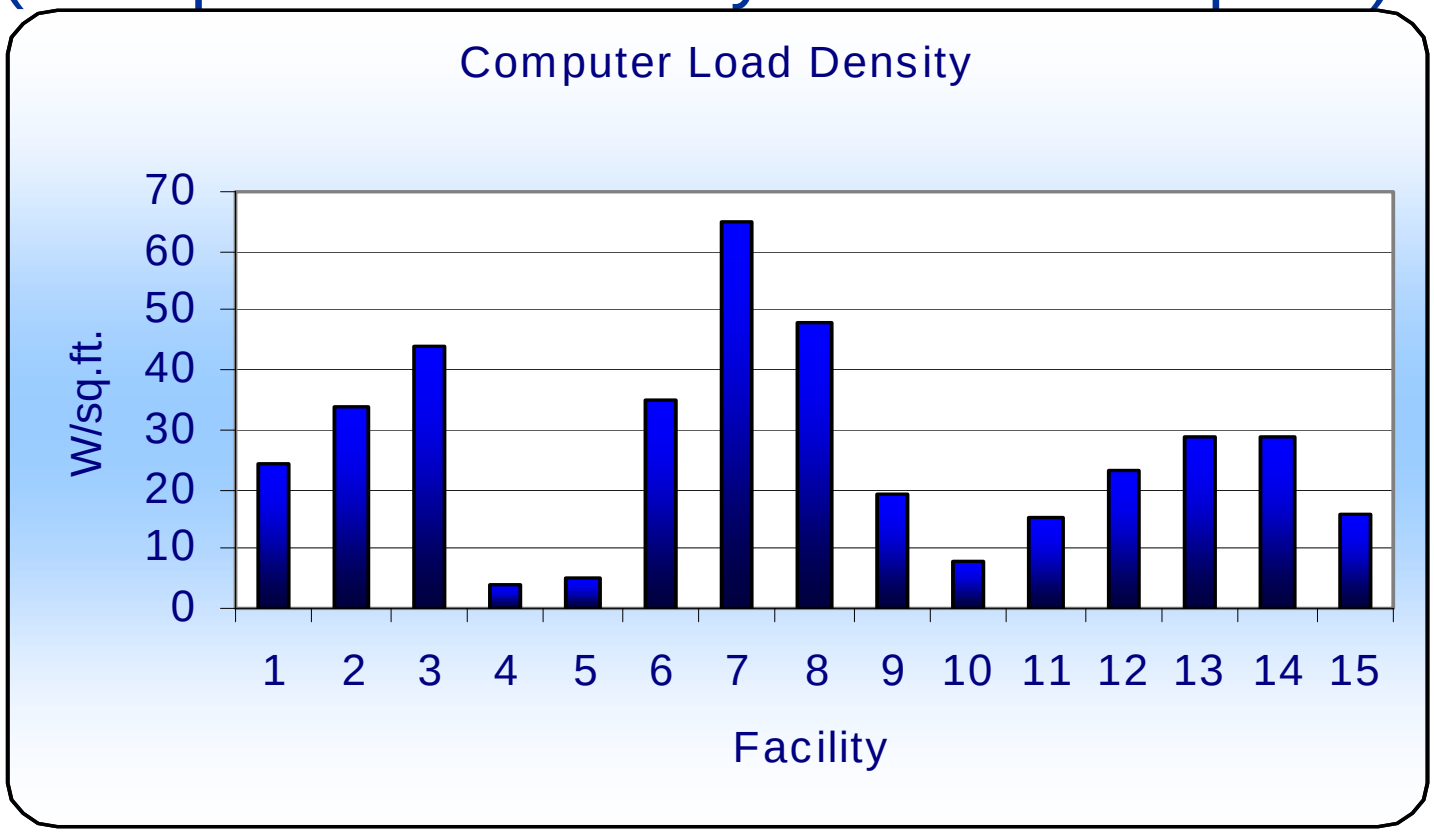
backup diesel generators

UPS = Uninterruptible Power Supply

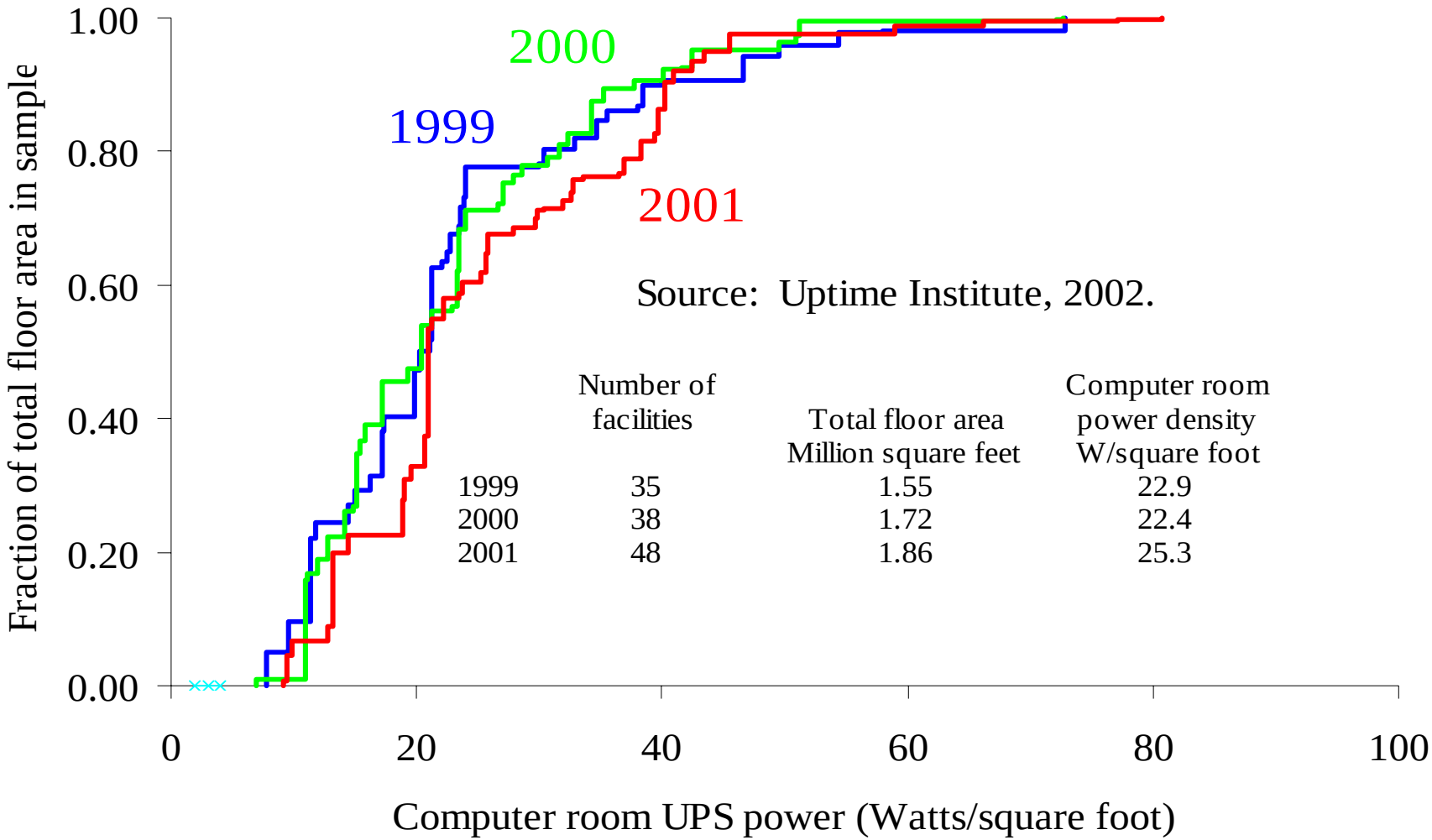
PDU = Power Distribution Unit;

Benchmarking Computer Loads

(W/Sq.Ft. of electrically active floor space)



Distribution of Computer Room Power Reported to Uptime Institute

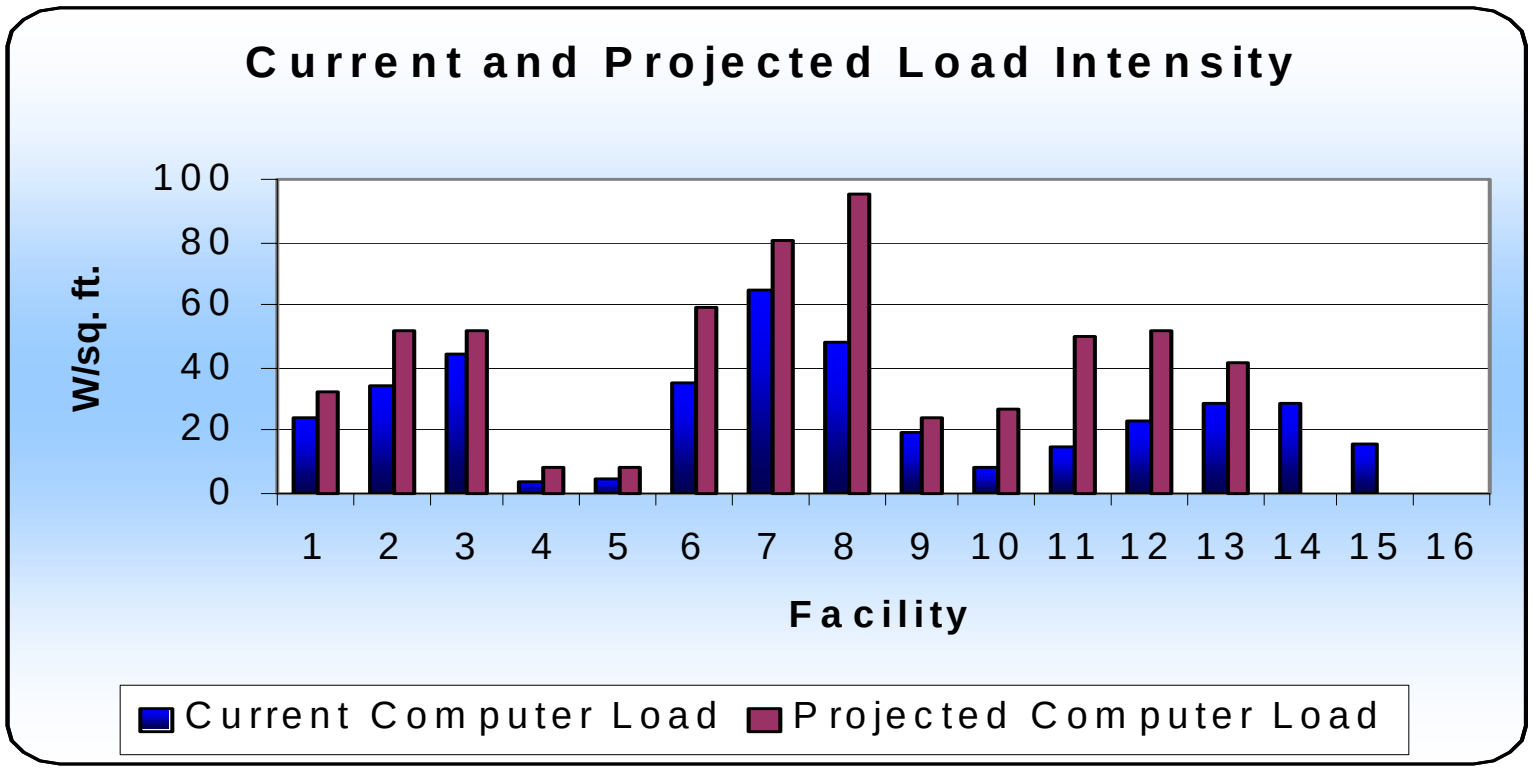


Source: Uptime Institute, 2002.

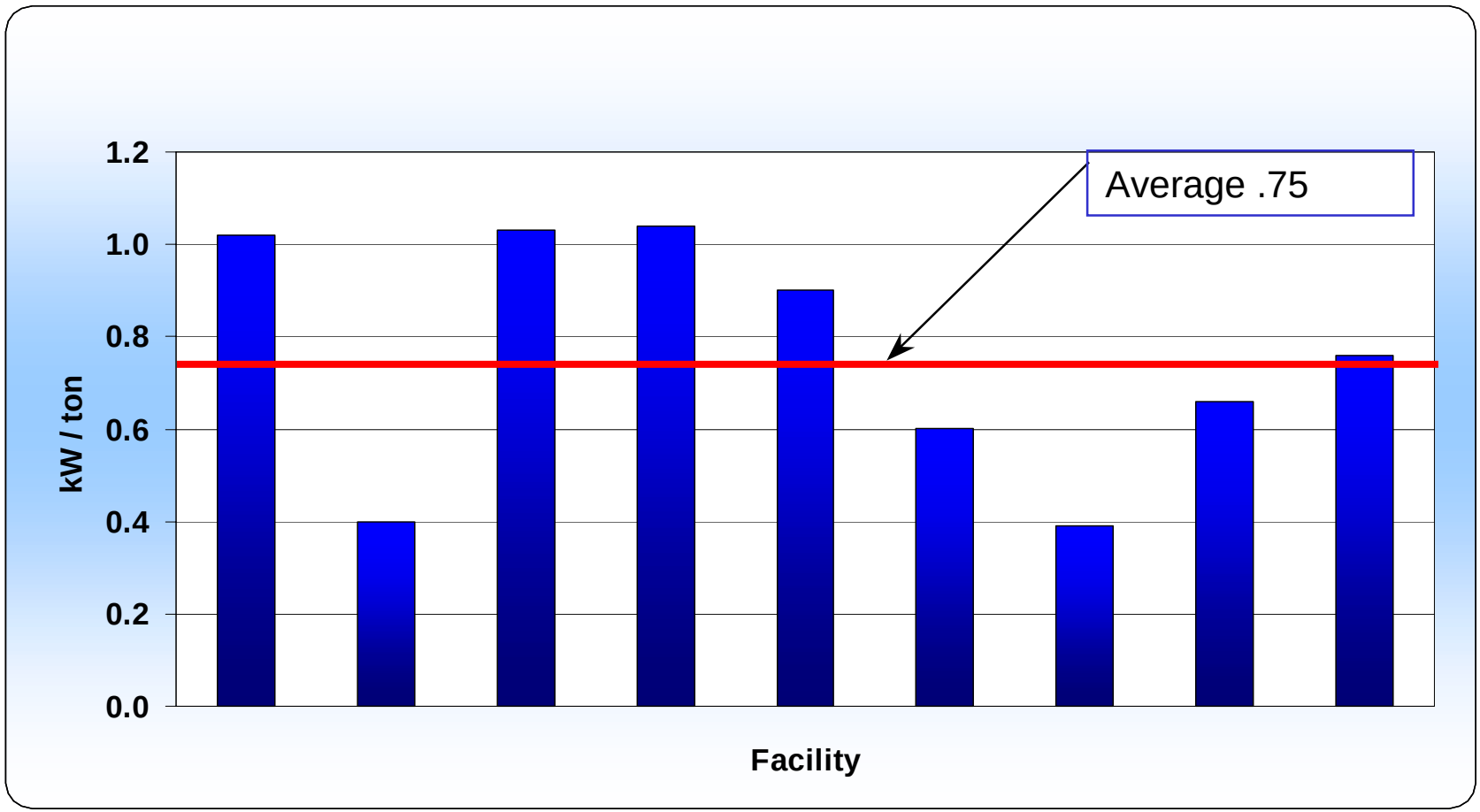
	Number of facilities	Total floor area Million square feet	Computer room power density W/square foot
1999	35	1.55	22.9
2000	38	1.72	22.4
2001	48	1.86	25.3

Projecting Computing Load When Fully Loaded

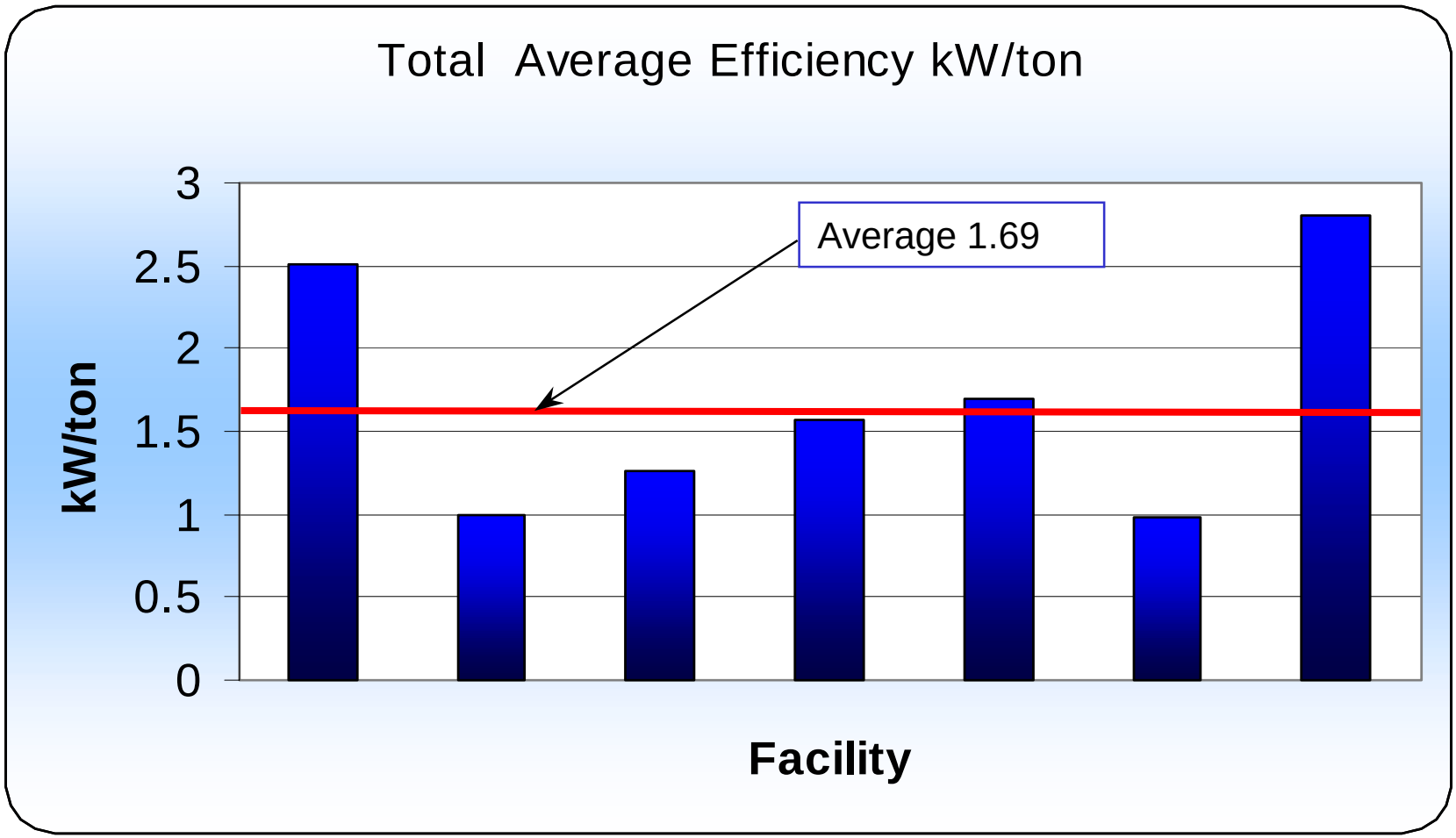
(W/Sq.Ft. of electrically active floor space)

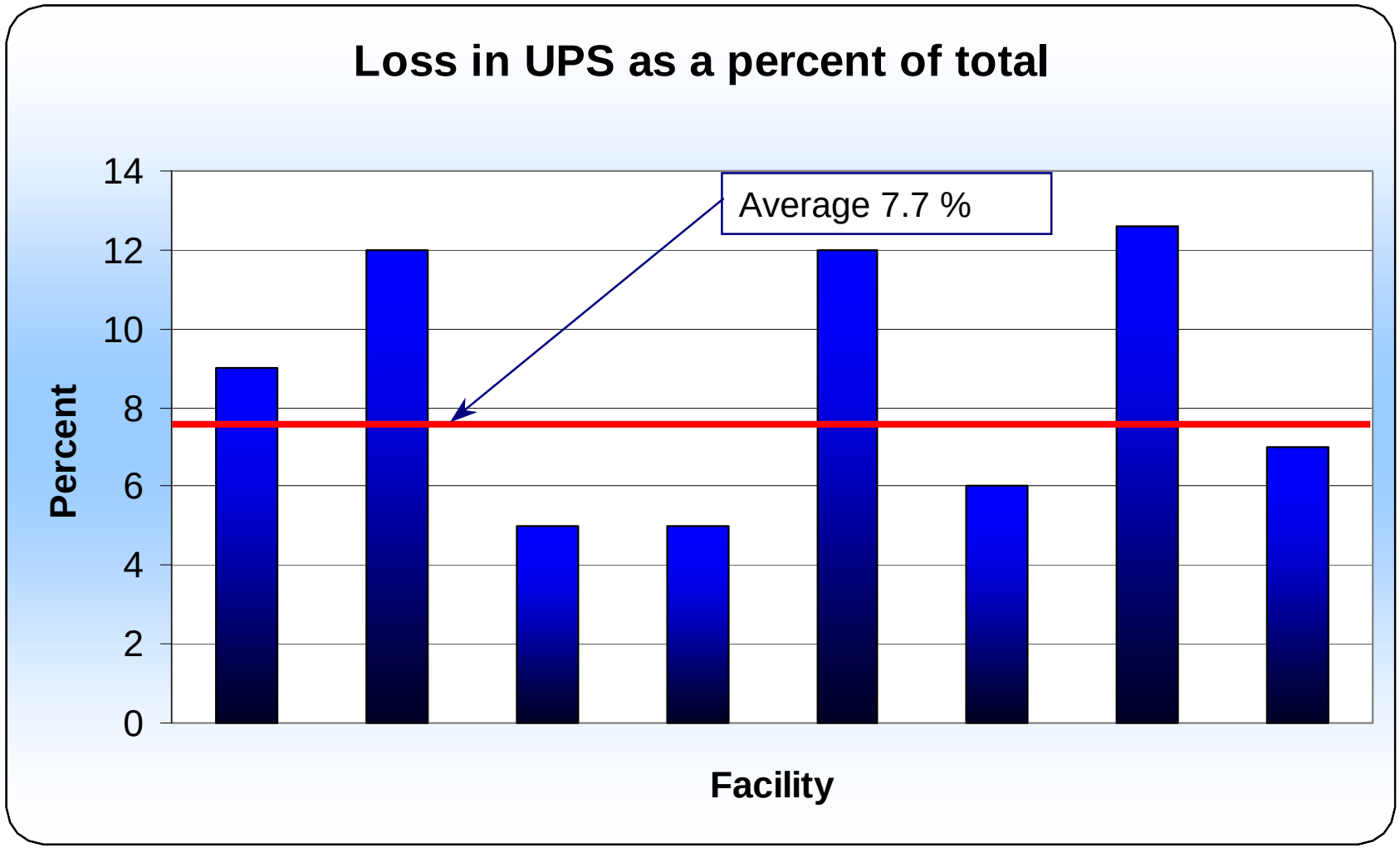


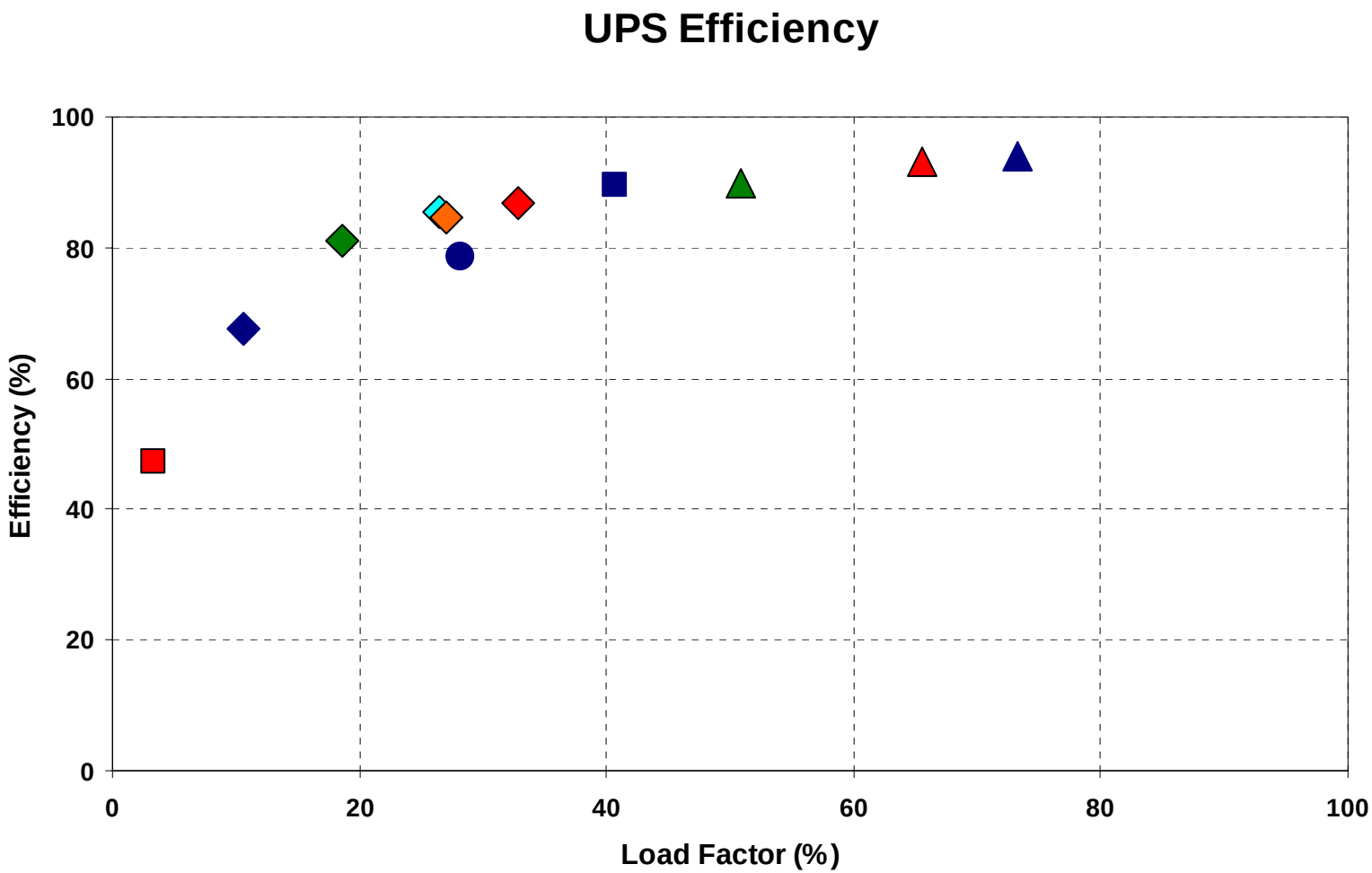
Chiller Comparison



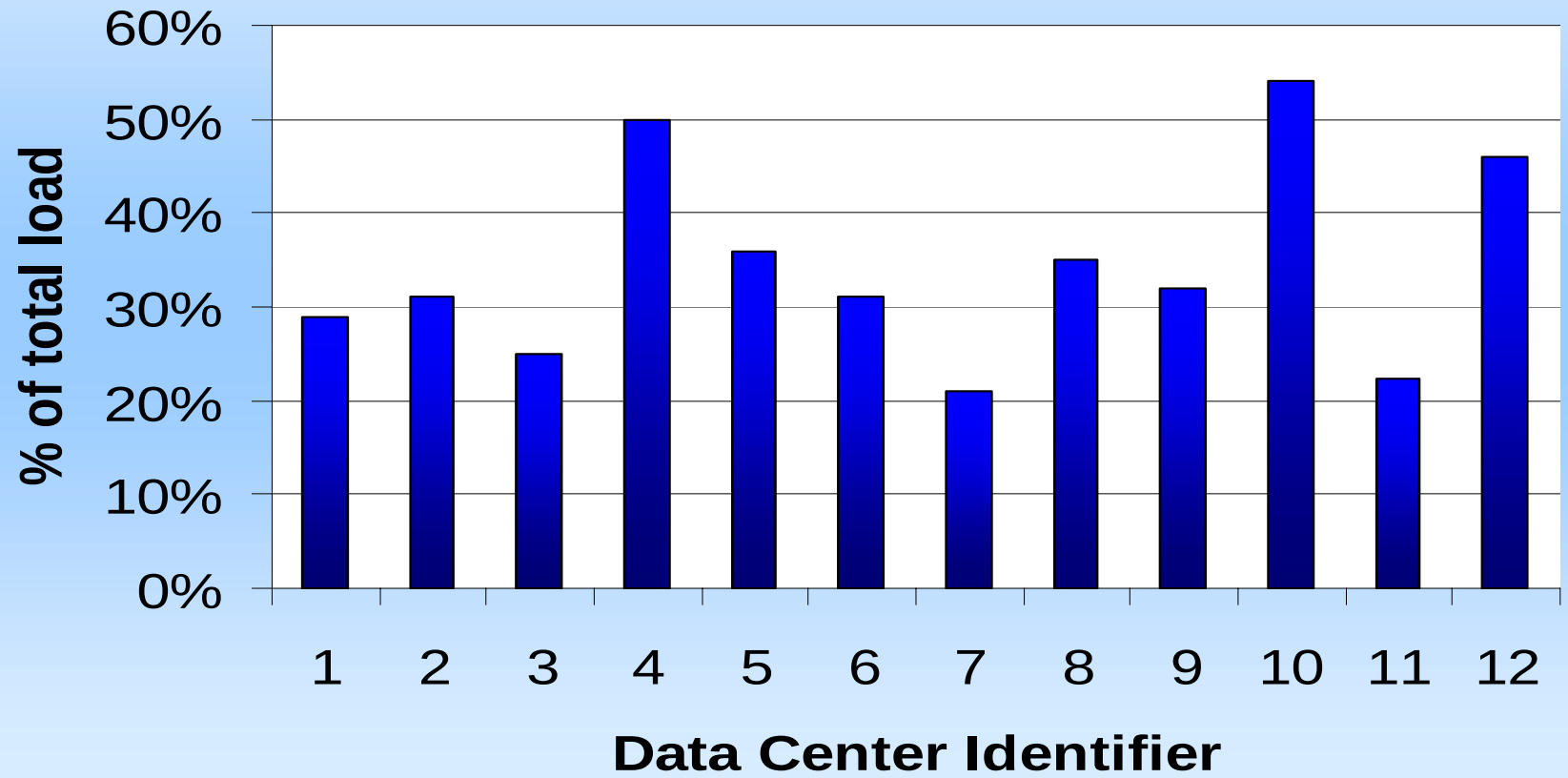
Total Chilled Water System Efficiency




Loss in UPS as a percent of total
Average 7.7 %
Percent
14
12
10
8
6
4
2
0
Facility


UPS Efficiency
Efficiency (%)
100
80
60
40
20
0
0
20
40
60
80
100
Load Factor (%)

HVAC (as a % of total load)



Index of Performance

The Uptime Institute proposes a metric termed:

Index of Performance = Building systems KW ÷ UPS Output

Metrics

- Computer load intensity:

  W/sq. ft. electrically active space

- UPS losses: %
- Chilled water: kW/ton; W/sq.ft.
- End use pie chart: W/end use; W/sq.ft.
- Occupancy:
  - % full (subjective)
  - % loaded – UPS or PDU

Possible Additional Benchmarks

- Computations per Kilowatt: mips/kW
- Nameplate vs. Actual Comparisons
  - IT Equipment
  - UPS
  - Chillers
  - Transformers
- Standby generator energy losses (heaters etc.)
- Others?

General Recommendations

- Benchmark to Know Where You Stand
- Life Cycle Cost Analysis
- Facilities partnership with IT Professionals
- Evaluate Load Spreading vs Compaction

Energy Efficiency Recommendations

- Match Systems to Real Loads
  - Efficient Operation at Part Loads
  - Ability to Add Load
  - Modular Design
- Use of Free Cooling
  - Plate/Frame Heat Exchanger
  - Cooling Towers
  - Air Side Economizers

Energy Efficiency Recommendations

Air Cooling

- Air Handler Efficiency
- Avoid simultaneous humidification/dehumidification

Energy Efficiency Recommendations, con't

Air Cooling - Air Management

- Hot/Cold Aisles
- Seal Openings
- Temperature and Humidity
- Take Advantage of Thermal Stratification

Efficient Reliability

- UPS systems
  - Configure to Operate Near Rated Load
  - Compare System Efficiencies at Expected Operation
  - Inertial vs Battery Systems
- Standby Generator Losses

Ideas for the Future

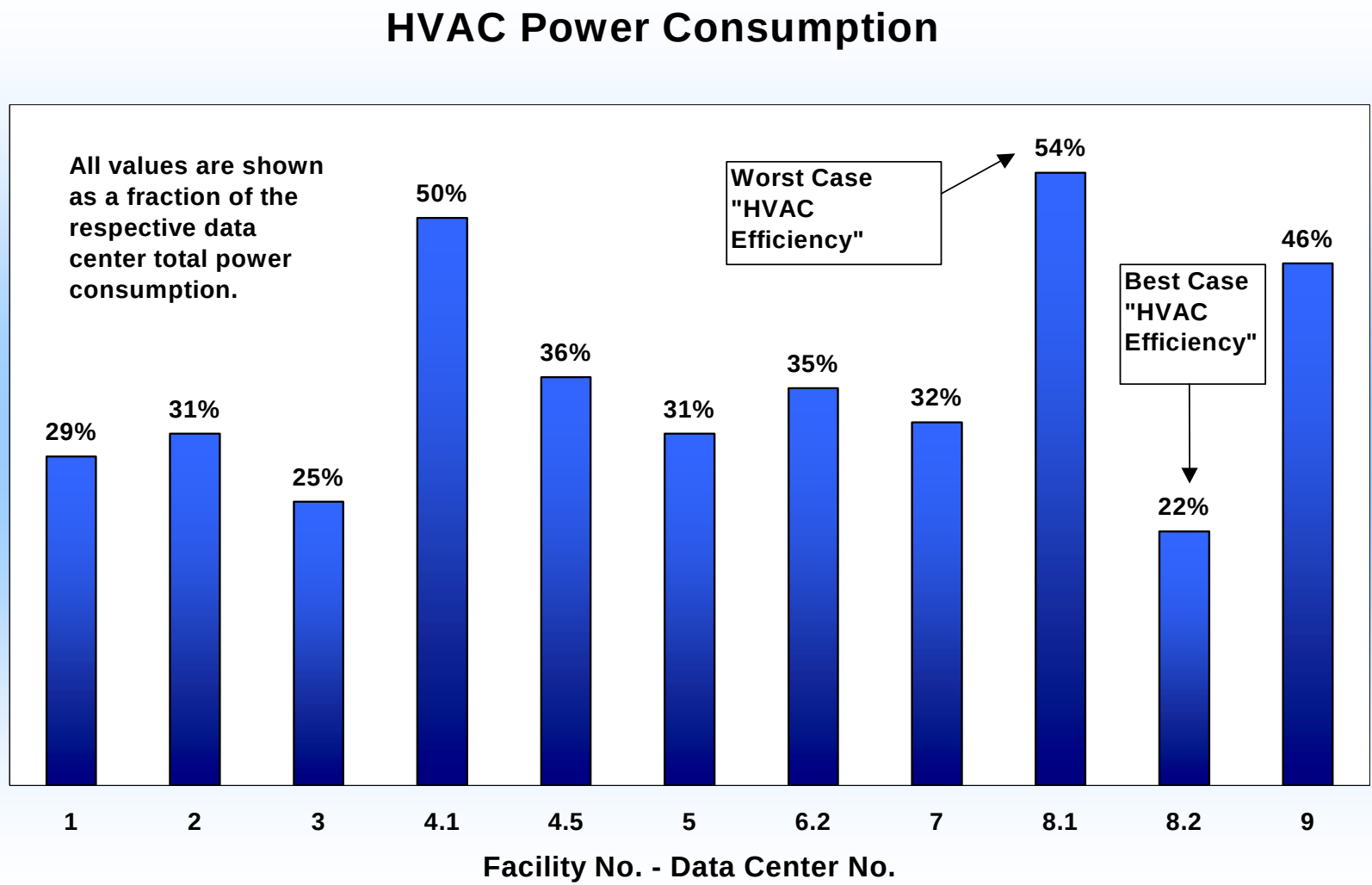
- Minimize Power Conversions
- Eliminate Individual Power Supplies
- Eliminate Individual Fans
- On-Site Generation (DC) with Grid Back-up

Case Study

Facility 8

- Two different HVAC schemes in one building
- State of the art Internet Server Hotel
- No raised floor/ Overhead cooling & Cabling
- Management commitment to efficient operation operation
- Located in mild climate

Facility 8 in Perspective



Facility 8 Site Characteristics

Data Center 8.1

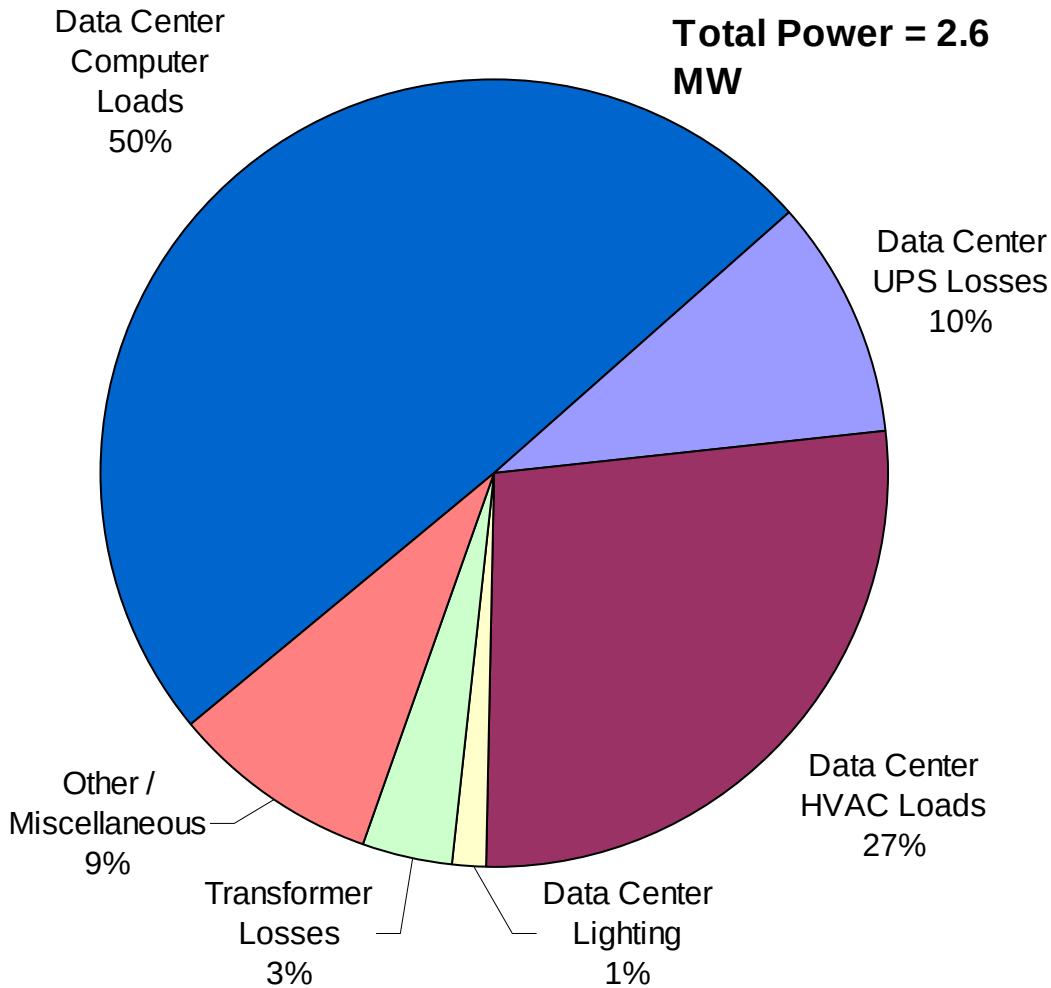
- 26,200 sq ft
- 6 UPS's – 3 per "side"
- Redundancy: n+1 at PDU level, n+2 at UPS level
- Overhead ducted air distribution
- Air-cooled constant volume CRAC units

Facility 8 Site Characteristics

Data Center 8.2

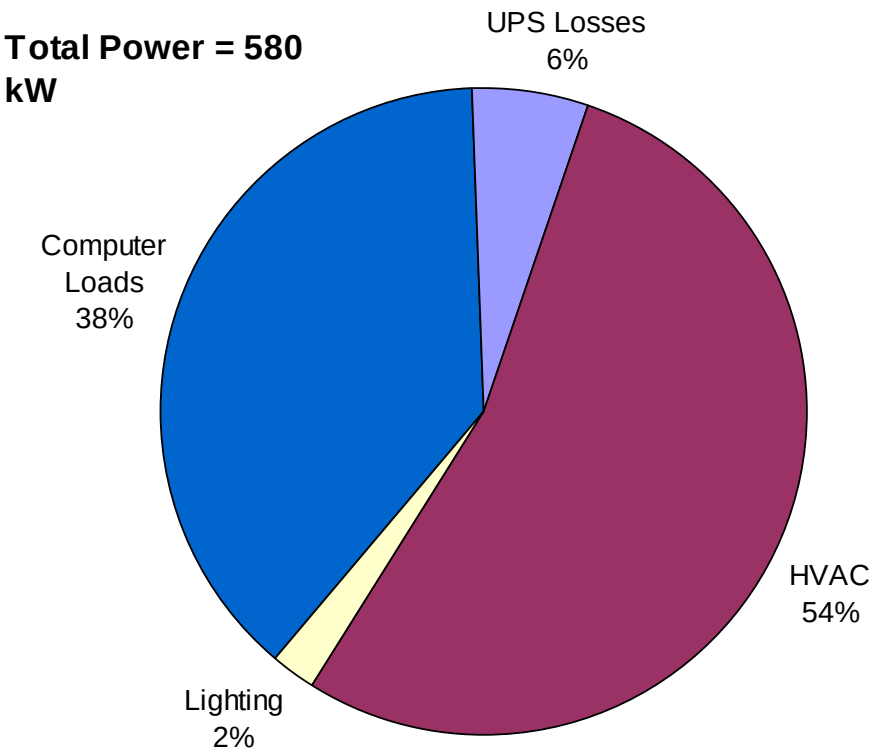
- 73,000 sq ft
- 5 UPS's
- Redundancy: n+1 at PDU level
- Overhead ducted air distribution
- Central Chilled Water Plant
- Central air handling system
- Variable speed chiller, secondary pumps, air handlers

Whole Building End Use

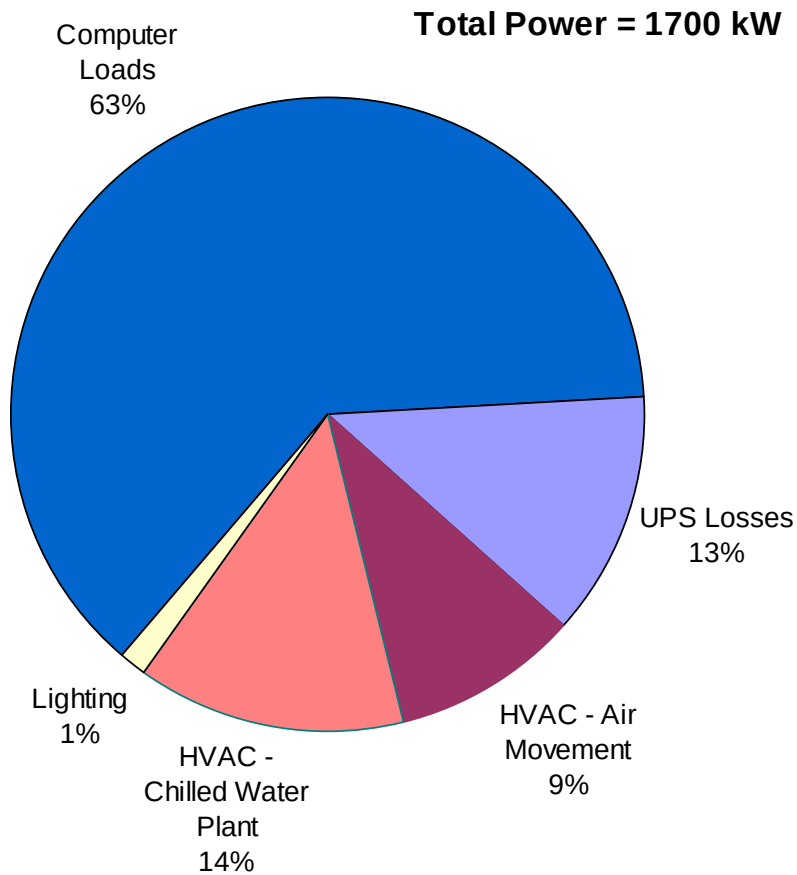


Facility 8 Electricity End-Use

Data Center 8.1



Data Center 8.2



Efficiency Metrics

Data Center 8.1

Metric	Value	Units
Data Center Computer Power Density	8.5	W/sf
Data Center Cooling Power Density	12	W/sf
Cooling kW : Computer Load kW	1.4	--

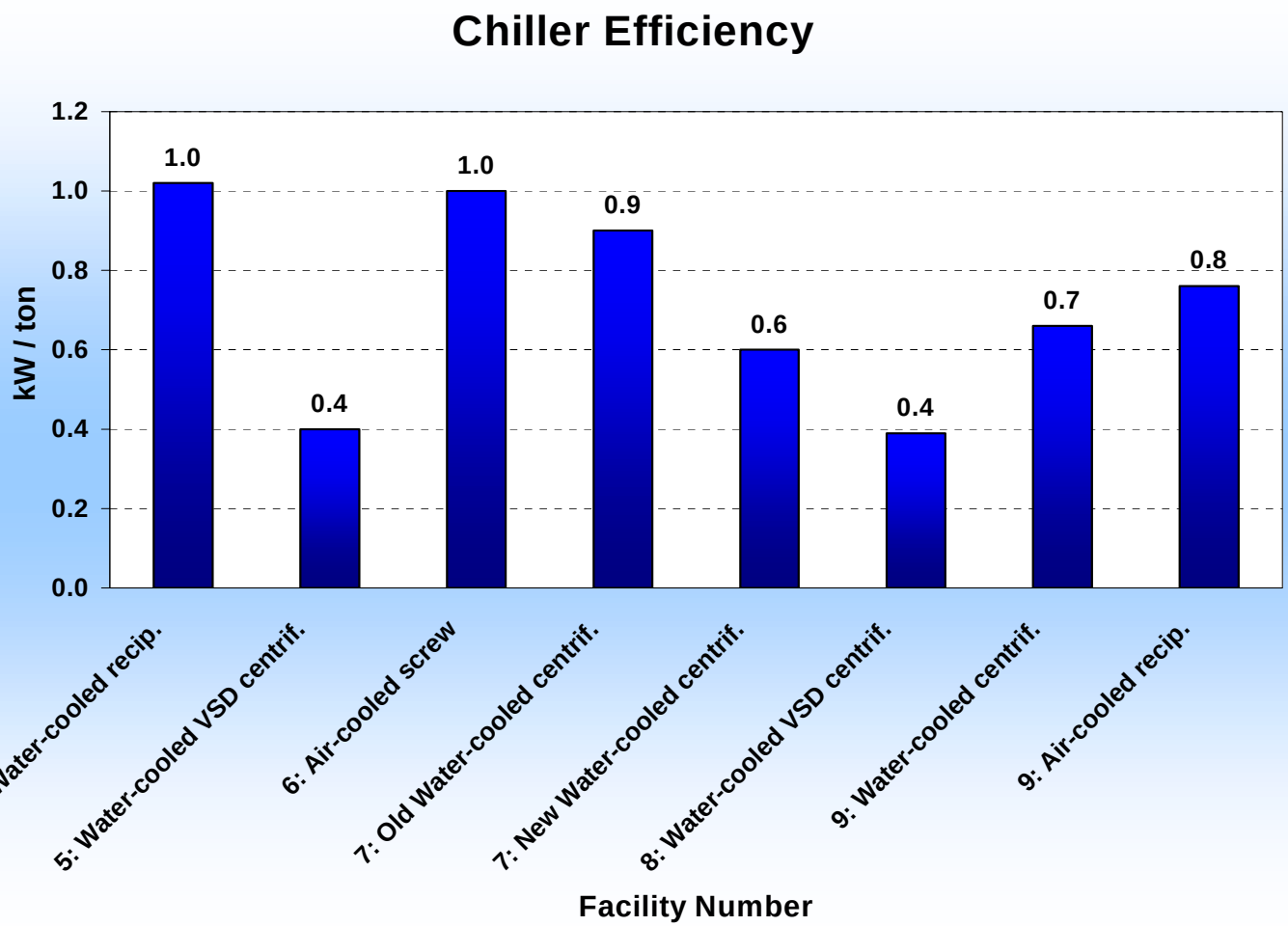
Data Center 8.2

Metric	Value	Units
Data Center Computer Power Load Density	14.5	W/sf
Data Center Cooling Power Load Density	5.3	W/sf
Cooling kW : Computer Load kW	0.4	--

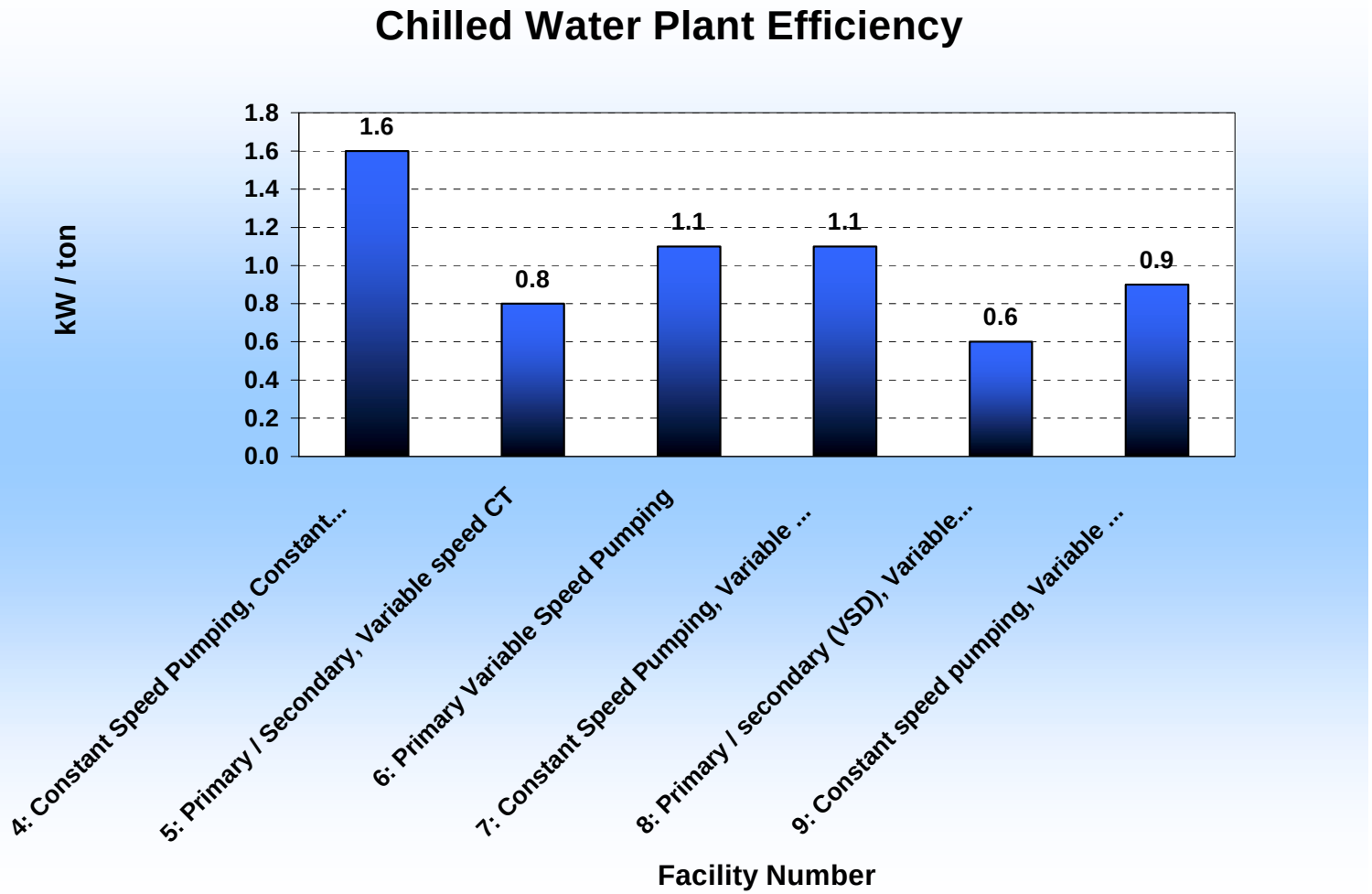
Efficiency Metrics

Chiller Efficiency	0.4 kW/ton
Chilled water plant Efficiency	0.6 kW/ton

Chiller Efficiency



Chilled Water Plant Efficiency



How did they do it?

Data Center 8.1

- Air cooled CRAC units
- No economizing
- Constant Speed Fans
- Humidification fighting itself
- All CRAC units on

Data Center 8.2

- Optimal central chilled water plant
- Optimal central air handling units
- Little humidity control
- Good control
- Data Monitoring – Gateways, EMCS

How can they do even better?

Data Center 8.1 Recommendations

- Disable humidification control
- Turn off CRAC units
- Rotate UPSs
- Space temperature setpoints

How can they do even better?

Data Center 8.2 Recommendations

- Monitoring - chiller, total chiller plant kW/Ton
- Run Cooling towers in parallel, nozzle replacement
- Chilled water setpoint
- Condenser water temperature reset

Common Findings

- Humidity Control and CRAC unit fighting
- Lighting Control
- Air side Economizing
- Variable Speed Drives – pumps, chillers, fans
- Control strategies - setpoints, cooling tower staging
- High ceilings important with Underfloor (thermal stratification)
- Air management common problem
- Low UPS loading

Data Center Energy Roadmap

- Input through workshops, conferences, and contacts with Industry professionals.
- Participation in design charrette facilitated by the Rocky Mountain Research Institute (RMI)
- Roadmap will be available on the LBNL website:

  http://datacenters.lbl.gov

Upcoming Activities

- Benchmark additional data centers in CA
- Best Practices identification
- Demonstrations (Possibly Air Management Improvement)
- Self Benchmarking Protocol
- UPS Efficiency
- Power Supplies Efficiency
- Standby Generator losses

Data Center websites

- http://Datacenters.lbl.gov
- www.upsite.com
- www.7X24exchange.org
- www.itherm.org
- http://www.me.gatech.edu/me/publicat/brochures/ochures/Mettl/Bro0302.htm